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This TOP describes procedures for measuring acoustical noise levels in Army helicopters. It covers tests for steady-state acoustical noise at crewstations and in the passenger compartment.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-106
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STEADY-STATE ACOUSTICAL NOISE MEASUREMENTS IN AVIATION SYSTEMS

1. SCOPE

This TOP describes procedures for measuring acoustical noise levels in Army helicopters. These measurements may be made to determine compliance with applicable specifications (e.g., MIL-STD-1294A[1]), evaluate the need for hearing protection, provide data for a hearing damage risk assessment, or determine the impact of the noise environment on speech intelligibility. It covers tests for steady-state acoustical noise at crewstations and in the passenger compartment. For acoustical noise measurements during maintenance operations (e.g., in the vicinity of ground power units, or on work platforms while the auxiliary power unit (APU) is operating), for measurement of the 85dB(A) contour around the helicopter, or for external acoustical noise signature (i.e., fly-by), see TOP 1-2-608[2].

[1]Reference letters/numbers match those in Appendix D, References.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Item	Requirement
a. Helicopter ground operating environment.	For those portions of the test that require the aircraft to be on the ground, or in close proximity to the ground, an environment is needed that is free from other noise sources such as other aircraft, ground vehicles, or ground support equipment.
b. Flight test environment (airspace).	When making measurements during flight, sufficient airspace must be available such that data can be collected without a requirement for turns or changes in altitude.

2.2 Instrumentation.

a. Devices for Measuring	Permissible Error of Measurement
Steady-state noise measuring system (see 2.2b).	±0.5 dB* from 20.0 Hz to 20 kHz.
Ambient temperature.	-10°C to +50°C ±1.0°C ±1°C (14°F to 122°F ±2°F).
Relative humidity (RH).	5% to 100% RH, ±3%.

b. Steady-state noise measuring system:

(1) Microphones: Microphones should meet the requirements of ANSI S1.4[a] and should be of the random incidence type with an essentially flat

*All decibel (dB) values in this TOP are referenced to 20 microPascals sound pressure level (re 20 µPa SPL)

frequency response from 20 Hz to 20 kHz. A microphone windscreen or nose cone may be needed for those conditions where air is moving past the microphone.

(2) Tape Recorder: Tape recorders shall meet the requirements of ANSI S6.1[b].

(3) Sound Level Meter: Sound level meters shall be Type I (precision sound level meter) as defined by ANSI S1.4.

(4) Octave-Band Filters: Octave band filter sets shall conform to requirements for Type E, Class II, as specified by ANSI S1.11[c].

(5) Calibrator: A calibrator capable of producing a tone at a known frequency (e.g., 250 Hz or 1 kHz) at a known sound level (±0.3 dB) shall be used.

(6) Spectrum Analyzer: An analyzer capable of displaying the signal received from either a microphone or tape recorder shall be used. It shall be capable of showing all frequencies from 20 Hz to 20 kHz, an A-weighting capability in accordance with ANSI S1.4, and octave band filtering.

3. REQUIRED TEST CONDITIONS.

3.1 Safety. During testing, only the minimum flight crew required for safe operation of the aircraft, and data collectors should be on board. All personnel should wear, at a minimum, sound attenuating helmets as required by AR 95-17[d].

3.2 Facilities.

a. Facilities shall meet the requirements specified in paragraph 2.1.

b. A sketch shall be made showing the layout of crewstations and the passenger/cargo compartment, indicating the location of microphones (see Appendix A).

c. The aircraft shall be operated with acoustical/thermal insulation intact and in place.

d. All subsystems and equipment which are normally operated continuously for more than 5 minutes per hour in flight shall be operating during flight noise data acquisition. This includes all onboard avionics and mission equipment. Heating/ventilating/air conditioning blowers shall be operating. If separate blowers are available that would not simultaneously operate, the configuration that produces the highest dB(A) level shall be used.

e. Noise measurements shall be made while the aircraft is at maximum design gross weight and at normal ±5% rated rotor speed.

3.3 Instrumentation

a. Assemble the noise measuring system prior to flight testing and assure that all components are in working order with a valid calibration certificate. Perform a system checkout by using the acoustical calibrator to present a sound of known frequency and sound pressure level. Assure that system output matches the signal source.

b. Microphones must be mounted or held such that vibration and shock transmitted to the microphone and preamplifier body do not contribute to the airborne noise signal.

c. Prepare an acoustical noise data form similar to the sample data sheet presented in Appendix B-1. Record the date, time and place of test trials, aircraft serial number, takeoff gross weight and any unusual features of the aircraft configuration (e.g., nonstandard rotor blades, additional instrumentation, or inoperative equipment that may affect test results).

4. TEST PROCEDURES

4.1 Method

a. Microphones shall be placed at or near the head positions of all crewstations and at a representative number of passenger stations. Whenever possible, noise measurements should be made with the crewmember absent and at a nominal ear position at a distance of 31.5 in. (80 cm) above the seat reference point or, if standing, at a height of 65 in. (165 cm). If the crewmember must be present, the microphone shall be placed 6 in. (15.24 cm) from the crewmember's left or right ear (using the side that exhibits the highest noise level). If practicable during each measurement, the microphone shall be rotated horizontally in a 6 to 12 in. (15 to 30 cm) diameter circle with the microphone facing up vertically.

b. Record pressure altitude, temperature, and relative humidity on the data collection sheet (Appendix B).

c. A calibration tone of known frequency and dB level shall be recorded for at least 30 seconds at the beginning and end of each recording tape.

d. All data shall be tape recorded. The recording time of each noise data sample shall be sufficient to produce a continuous 30 seconds or longer of analyzed data. Recordings shall be made while the aircraft is in a flight mode that produces a consistent noise level. Data shall not be collected during turns, altitude changes or other transient flight conditions, unless the transient condition itself is the flight mode under investigation.

4.2 Data Required

Data shall, at a minimum, be collected under the following conditions with doors/windows closed, and again with doors/windows open:

a. Ground tests:

(1) APU only running (if so equipped).
(2) APU running (if so equipped) with engines and rotors at ground idle.
(3) Engines and rotors at 100% rpm.

b. Flight tests:

(1) Hover in ground effect. The helicopter shall be flown at a height determined by a Z/D ratio of 0.4 ± 1 foot (0.3 meter) where:

Z = Height of the rotor above the ground

D = The main rotor diameter

(2) Level flight. Data shall be collected during straight and level flight at 40 knots indicated airspeed (KIAS) and again at increased airspeeds in 20 KIAS increments. The final data point shall be at the lower forward airspeed of either 0.9 V_H or 0.9 V_{NE} where:

V_H = maximum speed in level flight with maximum continuous power.

V_{NE} = never exceed speed.

5. DATA ANALYSIS.

Data recorded on magnetic tape shall be analyzed in the laboratory using a spectrum analyzer meeting the requirements of paragraph 2.2.b(6). At a minimum, the data from each test condition will be analyzed to determine:

a. Overall sound pressure level in dB

b. A-weighted sound pressure level in dB(A).

c. Sound pressure level within the octave bands with center frequency (Hz) from 63 to 16,000.

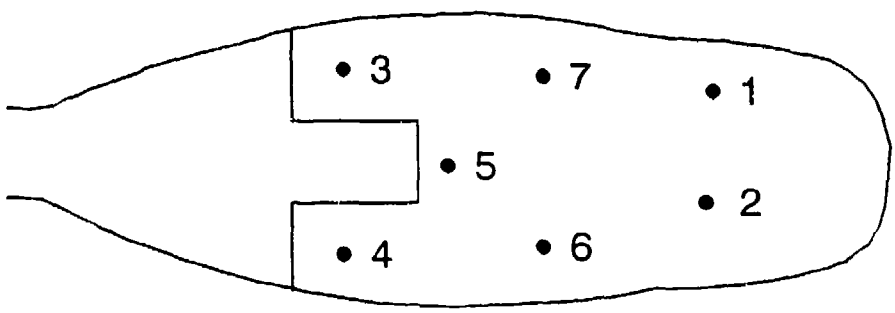
6. PRESENTATION OF DATA.

6.1 Transfer the analytical results from the spectrum analyzer (paragraph 5.) to a data analysis sheet as shown in Appendix C.

6.2 Compare the noise data with the limits for aircraft of the appropriate design gross weight as specified in MIL-STD-1294A, or with any special noise criteria established for the system under test (e.g., system specification). Denote those conditions that do not meet the criteria.

Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-TC-D, Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Commander, U.S. Army Aviation Technical Test Center, ATTN: STEAT-MP-P, Ft. Rucker, AL 36362-5276. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A. SAMPLE MICROPHONE LOCATION SKETCH



UH-1H Microphone Locations

1. 6 in. left of pilot's head.
2. Copilot's head location.
3. Crewchief/Gunner position.
4. Crewchief/Gunner position.
5. Passenger seat.
6. Passenger seat.
7. Passenger seat.

APPENDIX B. SAMPLE DATA COLLECTION SHEET FOR TAPE RECORDED DATA

Test Name_____ Date_____

TECOM Proj. No._____

Aircraft Type:_____ Serial No._____

Location_____

Take Off Gross Weight_____

Pressure Altitude_____Temp_____Humidity_____

A/C Configuration Notes_____

_____

Calibrator Type/Model:_____

Microphone(s) Type/Model:_____

Serial No(s):_____

Microphone Locations:_____

Tape Recorder/Model:_____ Serial No:_____

Tape ID	Test Condition	Start ID	Attenuator Setting

APPENDIX C. SAMPLE DATA ANALYSIS WORKSHEET FOR ACOUSTICAL NOISE (dB)

Test Name_____ *TECOM Proj. No.*_____ Date_____

A/C Type_____ A/C Serial No._____

Pressure Altitude_____ Tape ID_____

Temperature_____ Humidity_____

Flight Condition:

Center Freq (Hz)

Location	dB(A)	All Pass	31.5	63	25	250	500	1K	2K	4K	8K	16K
1												
2												
3												
4												
5												
6												
7												

APPENDIX D
REQUIRED REFERENCES

1. MIL-STD-1294A, Acoustical Noise Limits in Helicopters, 12 August 1985.

2. TECOM TOP 1-2-608, Sound Level Measurements, 17 July 1981.

REFERENCES FOR INFORMATION ONLY

a. ANSI S1.4-1983, Specification for Sound Level Meters, 17 February 1983.

b. ANSI S6.1 (also listed as recommended practice SAE J184), Qualifying a Sound Data Acquisition System, 18 October 1973.

c. ANSI S1.11-1986, Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters, 16 July 1986.

d. AR 95-17, The Army Aviation Life Support System Program, 15 May 1984.